

THE CARBON DICHOTOMY OF MARS VERSUS THE MARTIAN MOONS: AN IMPORTANT CLUE TO MARS' HISTORY. M.D. Fries¹, ¹NASA Astromaterials Research and Exploration Science (ARES), Johnson Space Center, Houston, TX. Email: marc.d.fries@nasa.gov

Introduction: The martian surface is one of the most carbon-depleted surfaces in the Solar System, yet the martian moons' surfaces contain enough carbon to be optically dark. This dichotomy has a range of implications, from the nature of martian surface redox chemistry, to support for a giant impact origin for the moons, to constraints on the flux of carbon between martian surface and atmosphere.

Martian Surface Carbon: On Earth, carbon cycling is typically considered as a system including flux between the mantle, surface, atmosphere, ocean, etc. The carbon cycle on Mars is simpler, with no modern-day oceans, a fully oxidized and much thinner atmosphere, no crustal recycling, and little or no volcanic input. It is scientifically useful to consider the carbon cycle of the martian surface in order to constrain the sinks and fluxes of martian carbon. Also, carbon input via meteoritic infall is a significant factor on Mars, whereas it is typically considered negligible on Earth.

The martian surface is strongly depleted in carbon, as measured by landed missions. Laboratory measurements of carbon degradation rates under Mars-ambient UV and/or galactic cosmic ray (GCR) flux show that carbon survival lifetimes are relatively short, and this has been offered as an explanation for the paucity of martian surface carbon.

Phobos/Deimos Carbon: The moons reside in a radiation environment similar to the martian surface, and yet reflectance measurements indicate carbon at the wt% level. Radar measurements indicate that the moons' surfaces are also unusually fine-grained. One possible explanation is that the surface compositions are dominated by dust/meteoritic infall due to their presence in Mars' gravity well. If correct, this would allow formation of the moons from a giant impact on Mars, followed by surficial decoration with carbon-rich material to yield their modern-day reflectance spectra. Recent papers state that formation by giant impact is favored over gravitational capture.

Implications: Regardless of the carbon's source, the martian moon surfaces contain $\sim 10^{7-9}$ more carbon than has been found on the martian surface, indicating that UV/GCR flux alone cannot explain the carbon depletion of the martian surface. UV/GCR may play a role in a broader redox system such as oxychlorine species generation, but this chemical system is poorly understood.

The oxidation rate of martian surficial carbon exceeds the meteoritic infall rate, estimated as 12E^5

kg/year by Flynn (1996), otherwise this carbon would accumulate to measurable amounts. This rate almost certainly has varied with time over the geological history of Mars. The martian moons may preserve a record of the infall rate, but this record is likely lost on the surface at least for species susceptible to oxidation.

Conclusions: The pronounced dichotomy between carbon concentrations on Mars' surface versus its moons provides valuable constraints on the history of the Mars/moons system. Considering the carbon cycle of the modern martian surface may allow constraints on the poorly understood redox chemistry of the martian surface. A better understanding of the composition and history of carbon on the martian moons will provide valuable insight into their formation and history.